National Imaging Associates, Inc.*	
Clinical guidelines **BRAIN (HEAD) CT**	**Original Date: September 1997**
CPT Codes: 70450 70460 70470	**Last Revised Date: ~~April~~ May 2021~~1~~**
Guideline Number: NIA_CG_002	**Implementation Date: January 2023~~2~~**

REDUCING RADIATION EXPOSURE

Brain CT/CTA are not approvable simultaneously unless they meet the criteria described below in the Indications for Brain CT/Brain CTA ~~combination studies~~**combination studies** section. **If there is a combination request* for an overlapping body part, either requested at the same time or sequentially (within the past 3 months) the results of the prior study should be:**

- **Inconclusive or show a need for additional or follow up imaging evaluation OR**
- **The office notes should clearly document an indication why overlapping imaging is needed and how it will change management for the patient.**

(*Unless approvable in the combination section as noted in the guidelines)

Important Note: Brain MRI is preferred to Brain CT in most circumstances where the patient can tolerate MRI and sufficient time is available to schedule the MRI examination. Assessment of subarachnoid hemorrhage, acute trauma, or bone abnormalities of the calvarium (fracture, etc.) may be better imaged with CT. CT is also appropriate in an urgent situation where MRI is not readily available (stroke, increased ICP, CNS infection).

‡~~‡~~ — ~~-~~*Designates ~~when~~ CT is indicated only when MRI is contraindicated or cannot be performed*

INDICATIONS FOR BRAIN CT

For evaluation of headache[1-5]

~~(ACR, 2019c; Holle, 2013; Quinones-Hinojosa, 2003; Schaefer, 2007; Wilbrink, 2009)~~

- Chronic headache with a change in character/pattern (e.g., more frequent, increased severity or duration) **‡~~‡~~‡**
- Cluster headaches or other trigeminal-autonomic cephalgias, i.e., paroxysmal hemicrania, hemicrania continua, short-lasting unilateral neuralgiform headache attacks (SUNCT/SUNA) imaging is indicated once to eliminate secondary causes[6] ~~(IHS, 2018)~~ **‡~~‡~~‡**
- ~~New a~~**A**cute headache, sudden onset:

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- With a personal or family history (brother, sister, parent, or child) of brain aneurysm or AVM (arteriovenous malformation)
- < 48 hours of "worst headache in my life" or "thunderclap" headache
  - Note: The duration of a thunderclap type headache lasts more than 5 minutes. Sudden onset new headache reaching maximum intensity within 2-3 minutes.
- Prior history of stroke or intracranial bleed
- Known coagulopathy or on anticoagulation

- New onset of headache with any of the following[1, 7, 8] ~~(ACR, 2019c; Micieli, 2020; Mitsikostas, 2016)~~:
  - Acute, new, or fluctuating neurologic deficits, such as sensory deficits, limb weakness, **abnormal reflexes,** speech difficulties, visual loss*, lack of coordination, or mental status changes or with signs of increased intracranial pressure (papilledema). ‡**See** background ‡‡‡
    ~~* Not explained by underlying ocular diagnosis, glaucoma, or macular degeneration~~
  - History of cancer or significantly immunocompromised ‡‡‡
  - Fever
  - Subacute head trauma
  - Age ≥ 50 ‡‡‡
  - New severe unilateral headache with radiation to or from the neck, associated with suspicion of carotid or vertebral artery dissection ‡‡‡
  - Related to activity or event (sexual activity, exertion, position) **and** -(new or progressively worsening~~)~~ ‡‡‡
  - Persistent or worsening during a course of physician-directed treatment[1, 9, 10] ~~(ACR, 2019c; Kuruvilla, 2015; Martin, 2011)~~ ‡‡‡

  Note: Neuroimaging warranted for atypical/complex migraine aura, but not for a typical migraine aura (see **background**)
- Special considerations in the pediatric population with persistent headache[11] ~~(Trofimova, 2018)~~:
  - Occipital location ‡‡‡
  - Age < 6 years ‡‡‡
  - Symptoms indicative of increased intracranial pressure, such as recurring headaches after waking with or without associated nausea/vomiting ‡‡‡
  - Documented absence of family history of headache ‡‡‡
  - Severe headache in a child with an underlying disease that predisposes to intracranial pathology (e.g., immune deficiency, sickle cell disease, neurofibromatosis, history of neoplasm, coagulopathy, hypertension, congenital heart disease)

For evaluation of neurologic symptoms or deficits[12]
~~(ACR, 2012a)~~

- Acute, new, or fluctuating neurologic symptoms or deficits, such as sensory deficits, limb weakness, **abnormal reflexes,** speech difficulties, visual loss*, lack of coordination, or mental status changes **(see background)**
  ~~* Not explained by underlying ocular diagnosis, glaucoma, or macular degeneration~~

For evaluation of known or suspected stroke or vascular disease[13-15]
~~(ACR 2017a, 2019a; Jauch, 2013)~~

- Known or suspected stroke with any acute, new, or fluctuating symptoms or deficits such as sensory deficits, limb weakness, speech difficulties, visual loss~~*~~, lack of coordination, or mental status changes **(see background)**

~~* Not explained by underlying ocular diagnosis, glaucoma, or macular degeneration~~

- Suspected stroke with first-degree family history of aneurysm (brother, sister, parent, or child) or known coagulopathy or on anticoagulation
- Symptoms of transient ischemic attack (TIA) (episodic neurologic symptoms such as sensory deficits, limb weakness, speech difficulties, visual loss, lack of coordination, or mental status changes) ~~‡‡‡~~
- Suspected acute subarachnoid hemorrhage (SAH)
- Follow-up for known hemorrhage, hematoma, or vascular abnormalities
- Suspected central venous thrombosis - see **background**[14-16] ~~(ACR, 2017a; Bushnell, 2014)~~ ~~‡‡‡~~
- Evaluation of neurological signs or symptoms in sickle cell disease[17-19] ~~‡‡‡~~ ~~(Arkuszewski, 2010; Mackin, 2014; Thust, 2014)~~
- **High stroke risk in sickle cell patients (2 - 16 years of age) with a transcranial doppler velocity > 200 ~~‡‡~~[19]** ~~when MRI is contraindicated or cannot be performed~~

For evaluation of known or suspected trauma[20-24]
~~(ACR, 2019f; Alrajhi, 2015; Jagoda, 2008; Menditto, 2012; Polinder, 2018)~~

- Known or suspected trauma or injury to the head with documentation of one or more of the following acute, new, or fluctuating:
  - Focal neurologic findings
  - Motor changes
  - Mental status changes
  - Amnesia
  - Vomiting
  - Seizures
  - Headache
  - Signs of increased intracranial pressure
- Known coagulopathy or on anticoagulation
- Known or suspected skull fracture by physical exam and/or prior imaging
- Repeat scan 24 hours post head trauma for anticoagulated patients with suspected diagnosis of delayed subdural hematoma
- Post concussive syndrome if persistent or disabling symptoms and imaging has not been performed
- Subacute or chronic traumatic brain injury with new cognitive and/or neurologic deficit ~~‡‡‡~~

For evaluation of suspected brain tumor, mass, or metastasis[25-27]
~~(ACR, 2018; Kerjnick, 2008; NCCN, 2020)~~

- Suspected brain tumor with any acute, new, or fluctuating neurologic symptoms or deficits such as sensory deficits, **abnormal ~~limb~~reflexes, limb** weakness, speech difficulties, visual loss~~*~~, lack of coordination or mental status changes **‡‡~~‡~~ (see background)**

~~* Not explained by underlying ocular diagnosis, glaucoma, or macular degeneration~~

- Suspected brain metastasis or intracranial involvement in patients with a history of cancer based on symptoms or examination findings (may include new or changing lymph nodes) **‡‡~~‡~~**
- **Histiocytic Neoplasms ~~(Erdheim-Chester Disease, Langerhans Cell Histiocytosis, and Rosai-Dorfman Disease)~~ for screening and/or with neurological signs or symptoms[28, 29]**
  - **Erdheim-Chester Disease**
  - **Langerhans Cell Histiocytosis**
  - **Rosai-Dorfman Disease~~[26]~~[28]**
- **Suspected Pituitary Tumors (Brain MRI is the study of choice if indicated) or Sella CT if MRI is contraindicated or cannot be performed**
- **S~~For s~~creening for known non-CNS Cancer and for screening of hereditary cancers syndromes (Brain MRI is the study of choice if indicated)**
- ~~Langerhans cell histiocytosis with visual, neurological, or endocrine abnormality; polyuria or polydipsia; suspected craniofacial bone lesions, aural discharge, or suspected hearing impairment/mastoid involvement[26] (Haupt, 2013, NCCN, 2020)~~

For evaluation of known brain tumor, mass, or metastasis

- Follow-up of known **CNS cancer (either primary malignant brain tumor or secondary brain metastasis) as per NCCN**[27] ~~malignant brain tumor ‡~~ **‡‡**
- Suspected recurrence with prior history of CNS cancer (either primary or secondary) based on neurological symptoms or examination findings **‡‡~~‡~~**
- **Follow-up of known low grade tumor (WHO I-II) (i.e., meningioma, glioma, astrocytoma, oligodendroglioma) ‡‡~~‡~~**
  - **For surveillance as per NCCN[27]**
  - **If symptomatic, new/changing signs or symptoms or complicating factors**

- ~~Patient with history of CNS cancer (either primary or secondary) and a recent course of chemotherapy, radiation therapy (to the brain), or surgical treatment within the last two (2) years (NCCN, 2020) ‡~~
- ~~Follow-up of known non-malignant tumor/lesion if symptomatic, new/changing signs or symptoms or complicating factors~~
- ~~Follow-up of known meningioma[30] (NHS, 2018) ‡~~
  - ~~If <2cm or heavily calcified at 2 years and 5 years~~
  - ~~> 2cm annually for 3 years and then scans at 5 years and 10 years~~
  - ~~Multiple meningiomas, annually~~
  - ~~After treatment (surgery or radiotherapy), post-operative if concern for residual tumor, every 6-12 months, then annually for 3-5 years based on WHO Grade (see background)~~

- Known pituitary tumors (Brain MRI is the study of choice if indicated) or Sella CT if MRI is contraindicated or cannot be performed
- Tumor monitoring in neurocutaneous syndromes as per tumor type ‡‡‡
- Bone tumor or abnormality of the skull[30] ~~(Gomez, 2018)~~
- Histiocytic Neoplasms to assess treatment response and surveillance of known brain/skull lesions[28, 29]
    - ~~(~~Erdheim-Chester Disease
    - ~~,~~ Langerhans Cell Histiocytosis
    - ~~, and~~ Rosai-Dorfman Disease ~~Langerhans cell histiocytosis~~[31] ~~(Haupt, 2013, NCCN, 2020)~~
    - ~~To assess treatment response and surveillance of known brain/skull lesions[28, 29]~~
    -

Indication for combination studies for the initial pre-therapy staging of cancer, OR active monitoring for recurrence as clinically indicated, OR evaluation of suspected metastases[27] ‡‡‡
~~(NCCN, 2020)~~

- ≤ 5 concurrent studies to include CT or MRI of any of the following areas as appropriate depending on the cancer: Neck, Abdomen, Pelvis, Chest, Brain, Cervical Spine, Thoracic Spine, or Lumbar Spine

For evaluation of known or suspected seizure disorder[32-35]
~~(Cendes, 2013; Gaillard, 2009; Krumholz, 2007; Ramli, 2015)~~

- New onset of seizures or newly identified change in seizure activity/pattern ‡‡‡ (Brain MRI is the study of choice if indicated)

For evaluation of known or suspected inflammatory disease or infection (e.g., meningitis or abscess)[36, 37]

~~(Lummel, 2016; Tunkel, 2008)~~ ‡‡‡

- Suspected intracranial abscess or brain infection with acute altered mental status OR positive lab findings (such as elevated WBCs) OR follow-up assessment during or after treatment completed ‡‡
- Meningitis with positive signs and symptoms (such as fever, headache, mental status changes, stiff neck) OR positive lab findings (such as elevated white blood cells or abnormal lumbar puncture fluid exam) ‡‡
- Suspected encephalitis with headache and altered mental status OR follow-up as clinically warranted ‡‡
- Endocarditis with suspected septic emboli ‡‡
- Central Nervous System (CNS) involvement in patients with known or suspected vasculitis or autoimmune disease with abnormal inflammatory markers or autoimmune antibodies ‡‡
- Suspected primary CNS vasculitis based on neurological signs and symptoms with completed infectious/inflammatory lab work-up ‡‡ [38, 39] ~~(Godasi, 2019; Zuccoli, 2011)~~
- Immunocompromised patient (e.g., transplant recipients, HIV with CD4 < 200, primary immunodeficiency syndromes, hematologic malignancies) with focal neurologic symptoms, headaches, behavioral, cognitive, or personality changes ‡‡ [40] ~~(Graham, 2000)~~

For evaluation of clinical assessment documenting cognitive impairment of unclear cause[41-44]
~~(AAN, 2017; Harvey, 2012; HQO, 2014; Narayanan, 2016)~~

- Change in mental status with a mental status score of either MMSE or MoCA of less than 26 or other similar mental status instruments */formal neuropsychological testing showing at least mild cognitive impairment AND a completed basic metabolic workup (such as thyroid function testing, liver function testing, complete blood count, electrolytes, and B12) ‡‡~~‡~~
  * Other examples include: Mini-Cog, Memory Impairment Screen, Saint Louis University Mental Status Examination (SLUMS), Brief Alzheimer's Screen (BAS), Blessed Dementia Scale (BDS), Clinical Dementia Rating (CDR)~~Other examples include: Ottawa 3DY (O3DY), Brief Alzheimer's Screen (BAS), Blessed Dementia Scale (BDS), caregiver-completed AD8 (cAD8), Brief Cognitive Rating Scale (BCRS), Clinical Dementia Rating (CDR)~~[45, 46] ~~(Carpenter, 2011; McDougall, 1990)~~

For evaluation of movement disorders[47]
~~(Mascalchi, 2012)~~

- Acute onset of a movement disorder with concern for stroke or hemorrhage ‡‡~~‡~~
- For evaluation of Parkinson's disease with atypical feature or other movement disorder (i.e., suspected Huntington disease, chorea, parkinsonian syndromes, hemiballismus, atypical dystonia) to exclude an underlying structural lesion ‡‡~~‡~~

Note: CT has limited utility in the chronic phases of disease. Brain MRI is the study of choice if indicated. Imaging is not indicated in essential tremor, Tourette' syndrome or isolated focal dystonia (e.g., blepharospasm, cervical dystonia, laryngeal dystonia, oromandibular dystonia, writer's dystonia).[48-50] ~~(Albanese, 2011; Comella, 2019; Sharifi, 2014)~~

For evaluation of cranial nerve and visual abnormalities (Brain MRI is the study of choice if indicated)

- Anosmia (loss of smell) or dysosmia (documented by objective testing) that is persistent and of unknown origin[51, 52] ~~(Policeni, 2017; Rouby, 2011)~~ ‡‡~~‡~~
- Abnormal eye findings on physical or neurologic examination (papilledema, nystagmus, ocular nerve palsies, new onset anisocoria, visual field deficit, etc.)[53] ~~(Chang, 2019)~~ ‡‡~~‡~~
  Note: See background~~Not explained by underlying ocular diagnosis, glaucoma, or macular degeneration~~
- Binocular diplopia with concern for intracranial pathology[54] after comprehensive eye evaluation ~~(Iliescu, 2017)~~ ‡‡~~‡~~
- Childhood strabismus with development delay or abnormal fundoscopic exam to rule out intracranial abnormalities[55, 56] ~~(Kadom, 2008; Yoon, 2019)~~ ‡‡~~‡~~
- Horner's syndrome with symptoms localizing the lesion to the central nervous system[57] ~~(Lee, 2007)~~ ‡‡~~‡~~
- Evaluation of cranial nerve palsy/neuropathy/neuralgia when thought to be due to tumor, stroke, or bony abnormalities of the skull base or when MRI is contraindicated or cannot be performed[51] ~~(ACR, 2017b)~~
- Bulbar or pseudobulbar symptoms ‡‡~~‡~~

For evaluation of known or suspected congenital abnormality (such as craniosynostosis, neural tube defects)[58-60]

~~(Ashwal, 2009; Marchese, 2017; Vinocur, 2010)~~

- Known or suspected congenital abnormality with any acute, new, or fluctuating neurologic, motor, or mental status changes
- For initial evaluation of a suspected Arnold Chiari malformation ‡‡‡
- Follow-up imaging of a known type II or type III Arnold Chiari malformation ‡‡‡. For Arnold Chiari type I, follow-up imaging only if new or changing signs/symptoms[61, 62] ~~103, 145~~
-
- Evaluation of macrocephaly in an infant/child <18 with previously abnormal US, abnormal neurodevelopmental examination ~~(Tan, 2018)~~,[63] signs of increased ICP or closed anterior fontanelle ‡‡‡
- Microcephaly in an infant/child < 18 ‡‡‡
- ~~Evaluation of the corticomedullary junction in Achondroplasia[59, 60] (Dougherty,2018; Kubota, 2021) ‡~~
- Craniosynostosis and other head deformities
- Evaluation of the corticomedullary junction in Achondroplasia[64, 65] ‡‡‡
- Cerebral palsy if etiology has not been established in the neonatal period, there is change in the expected clinical or developmental profile or concern for progressive neurological disorder[66, 67]
-
- Prior treatment or planned treatment for congenital abnormality
  Note: For evaluation of known or suspected hydrocephalus please see section on CSF abnormalities.

Cerebral Spinal Fluid (CSF) Abnormalities

- ~~•~~ Evaluation of suspected hydrocephalus with any acute, new, or fluctuating neurologic, motor, or mental status changes
- Known hydrocephalus†
- Known or suspected normal pressure hydrocephalus (NPH)[68] ~~(Damasceno, 2015)~~
  - With symptoms of gait difficulty, cognitive disturbance, and urinary incontinence
- Follow-up shunt evaluation[69-71] ~~(Kamenova, 2018; Pople, 2002, Reddy, 2014)~~
  - Post operativity if indicated based on underlying disease and pre-operative radiographic findings and/or
  - 6-12 months after placement and/or
  - With neurologic symptoms that suggest shunt malfunction
- Evaluation of known or suspected cerebrospinal fluid (CSF) leakage[72] ~~(Severson, 2019)~~
- Cisternography for intermittent and complex CSF rhinorrhea/otorrhea. CSF fluid should always be confirmed with laboratory testing (Beta-2 transferrin assay)[73, 74] ~~(Kułakowska, 2011; Selcuk, 2010)~~
- Suspected spontaneous intra-cranial hypotension with distinct postural headache other symptoms include: nausea, vomiting, dizziness, tinnitus, diplopia neck pain or imbalance[75] ~~(Gordon, 2019)~~ ‡‡‡

†Often congenital, but can present later in life; or less commonly acquired secondary to tumor, stroke, trauma, infection, etc.[76] ~~(NORD, 2014)~~

Pre-operative/procedural evaluation for brain/skull surgery

- Pre-operative evaluation for a planned surgery or procedure

Post-operative/procedural evaluation

- A follow-up study may be needed to help evaluate a patient's progress after treatment, procedure, intervention, or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.

Other Indications[19, 77-79]

~~(DeFoer, 2006; Kattah, 2009; Tarrant, 2008; Thust, 2014)~~

- Vertigo associated with any of the following: ~~‡‡‡~~
  - Signs or symptoms suggestive of a CNS lesion (ataxia, visual loss, double vision, weakness or a change in sensation)[80, 81] ~~(Welgampola, 2019; Yamada, 2019)~~
  - Progressive unilateral hearing loss
  - Risk factors for cerebrovascular disease with concern for stroke
  - After full neurologic examination and vestibular testing with concern for central vertigo (i.e., skew deviation, vertical nystagmus, head thrust test, videonystagmography (VNG)/ electronystagmography (ENG))
- Diagnosis of central sleep apnea on polysomnogram ~~‡‡‡~~
  - Children > 1 year[82] ~~(Felix, 2016)~~
  - Adults in the absence of heart failure, chronic opioid use, high altitude, or treatment emergent central sleep apnea AND concern for a central neurological cause (Chiari malformation, tumor, infectious/inflammatory disease) OR with an abnormal neurological exam[83] ~~(Malhotra, 2010)~~
- Syncope with clinical concern for seizure or associated neurological signs or symptoms[84-87] ~~(ACP, 2012; AFP, 2020; Al Nsoor, 2010; Strickberger, 2006)~~ ~~‡‡‡~~
- Cyclical vomiting syndrome or abdominal migraine with any localizing neurological symptoms[88-90] ~~(Angus-Leppan, 2018; Li, 2018; Venkatesan, 2019)~~ ~~‡‡‡~~
- Soft tissue mass of the head with nondiagnostic initial evaluation (ultrasound and/or radiograph)[91-93] ~~(ACR, 2017c; Kim, 2019; Zhang, 2018)~~ ~~‡‡‡~~
- Psychological changes with neurological deficits on exam or after completion of a full neurological assessment that suggests a possible neurologic cause[94] ~~(ACR, 2019b)~~ ~~‡‡‡~~
- Global developmental delay or developmental delay with abnormal neurological examination in a child < 18 years[95, 96] ~~(Ali, 2015; Momen, 2011)~~ ~~‡‡‡~~
- ~~Cerebral palsy if etiology has not been established in the neonatal period, there is change in the expected clinical or developmental profile or concern for progressive neurological disorder[90, 91] (Ashwal, 2004; NICE, 2020)~~
- Unexplained event (BRUE) formerly apparent life-threatening event (ALTE) in infants < 1 year with concern for neurological cause based on history and exam[97] ~~(Tieder, 2016)~~ ~~‡‡‡~~
  Note: Imaging is not indicated in low-risk patients
- Prior to lumbar puncture in patients with suspected increased intracranial pressure or at risk for herniation

Indications for Combination Studies[13, 14]

Note: These body regions might be evaluated separately or in combination as documented in the clinical notes by physical examination findings (e.g., localization to a particular segment of the neuroaxis), patient history, and other available information, including prior imaging.

~~(ACR, 2017a, 2019a)~~

- Exception: Approved indications as noted above and being performed in a child under 8 years of age who will need anesthesia for the procedure and there is a suspicion of concurrent intracranial pathology[98] ~~(Lawson, 2000)~~

- **Brain CT/Neck CTA**
  - Recent ischemic stroke or transient ischemic attack
  - Suspected carotid or vertebral artery dissection with focal or lateralizing neurological deficits

- **Brain CT/Brain CTA**
  - Recent ischemic stroke or transient ischemic attack
  - Acute, sudden onset of headache with personal history of a vascular abnormality or first-degree family history of aneurysm
  - Headache associated with exercise or sexual activity[6] ~~(IHS, 2018)~~ ~~‡‡‡~~
  - Suspected venous thrombosis (dural sinus thrombosis) – Brain CTV (see **background**) ~~‡‡‡~~
  - Neurological signs or symptoms in sickle cell patients ~~‡‡‡~~
  - High stroke risk in sickle cell patients (2 - 16 years of age) with a transcranial doppler velocity > 200 ~~‡‡~~ [19] ~~when MRI is contraindicated or cannot be performed~~
  - ~~o~~

- **Brain CT/Brain CTA/Neck CTA**
  - Recent stroke or transient ischemic attack (TIA)
  - Suspected carotid or vertebral artery dissection with focal or lateralizing neurological deficits

*Note: MRA and CTA are generally comparable noninvasive imaging alternatives each with their own advantages and disadvantages.

  - Brain MRI can alternatively be combined with Brain CTA/Neck CTA.

- **Brain CT/Orbit CT**
  - Optic neuropathy or unilateral optic disk swelling of unclear etiology to distinguish between a compressive lesion of the optic nerve, optic neuritis, ischemic optic neuropathy (arteritic or non-arteritic), central retinal vein occlusion, or optic nerve infiltrative disorders[99] ~~(Behbehani, 2007)~~ ~~‡‡‡~~
  - Bilateral optic disk swelling (papilledema) with visual loss[100] ~~(Margolin, 2019)~~ ~~‡‡‡~~

- Brain CT/~~-~~Cervical CT/Thoracic CT/Lumbar CT (any combination) ‡‡~~‡~~
  - For initial evaluation of a suspected Arnold Chiari malformation
  - Follow-up imaging of a known type II or type III Arnold Chiari malformation. For Arnold Chiari type I, follow-up imaging only if new or changing signs/symptoms[61, 62] ~~62, 63~~
  - Oncological Applications (e.g., primary nervous system, metastatic)
    - Drop metastasis from brain or spine (CT spine imaging in this scenario is usually CT myelogram) see **background**
    - Suspected leptomeningeal carcinomatosis (see background)[101]
    - Tumor evaluation and monitoring in neurocutaneous syndromes ~~– See background~~
  - CSF leak highly suspected and supported by patient history and/or physical exam findings (known or suspected spontaneous (idiopathic) intracranial hypotension (SIH), post lumbar puncture headache, post spinal surgery headache, orthostatic headache, rhinorrhea or otorrhea, or cerebrospinal-venous fistula - CT spine imaging in this scenario is usually CT myelogram)[102]

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BACKGROUND

Computed tomography (CT) is an imaging technique used to view the structures of the brain and is useful in evaluating pathologies in the brain. It provides more detailed information on head trauma, brain tumors, stroke, and other pathologies in the brain than regular radiographs.

CT scan for Headache – Generally, magnetic resonance imaging is the preferred imaging technique for evaluating the brain parenchyma, and CT is preferable for evaluating subarachnoid hemorrhage. CT is faster and more readily available than MRI and is often used in urgent clinical situations. Neurologic imaging is warranted in ~~patient~~**individual**s with headache disorders along with abnormal neurologic examination results or predisposing factors for brain pathology.

Headache timeframes and other characteristics – Generally, acute headaches are present from hours to days, subacute from days to weeks, and chronic headaches for more than 3 months. Acute severe headaches are more likely to be pathological (e.g., SAH, cerebral venous thrombosis) than non-acute (e.g., migraine, tension-type). Headaches can also be categorized as new onset or chronic/recurrent. Non-acute, new onset headaches do not require imaging unless there is a red flag as delineated above. Incidental findings lead to additional medical procedures and expense that do not improve ~~patient~~**individual** well-being. Primary headache syndromes, such as migraine and tension headaches, are often episodic with persistent or progressive headache not responding to treatment, requiring further investigation (e.g., new daily persistent headache). Imaging is indicated in chronic headaches if there is a change in the headache frequency (number of headaches episodes/month), duration of each episode, severity of the headaches or new characteristics, such as changing aura or associated symptoms.[1, 6, 103-105] ~~(ACR, 2019c; IHS, 2018; Jang, 2019; Spierings, 2003; Tyagi, 2012).~~

Migraine with Aura[6, 7, 106] ~~- (Hadjikhani, 2019; IHS, 2018; Micieli, 2020) –~~ The headache phase of a migraine is preceded and/or accompanied by transient neurological symptoms, referred to as aura, in at least a third of migraine attacks. The most common aura consists of positive and/or negative visual phenomena, present in up to 99% of the ~~patient~~**individual**s. Somatosensory is the secondary most common type of aura (mostly par~~a~~esthesia~~s~~ in an upper limb and/or hemiface). Language/speech (mainly paraphasia and anomic aphasia) can also be affected. These neurological symptoms typically evolve over a period of minutes and may last up to 20 minutes or more. The gradual evolution of symptoms is thought to reflect spreading of a neurological event across the visual and somatosensory cortices. Characteristically, the aura usually precedes and terminates prior to headache, usually within 60 minutes. In others, it may persist or begin during the headache phase. ICHD-3 definition of the aura of migraine with typical aura consists of visual and/or sensory and/or speech/language symptoms, but no motor, brainstem, or retinal symptoms and is characterized by gradual development, duration of each symptom no longer than one hour, a mix of positive and negative features and complete reversibility. Atypical or complex aura includes motor, brainstem, monocular visual disturbances, or ocular cranial nerve involvement (hemiplegic migraine, basilar migraine/brainstem aura, retinal migraine, ophthalmoplegic migraine) and secondary causes need to be excluded. Additional features of an aura that raise concern for an underlying vascular etiology include late age of onset, short duration, evolution of the focal symptoms, negative rather than positive visual phenomenon, and history of vascular risk factors.

Neurological Deficits ~~–~~:
Examples of abnormal reflexes related to upper motor neuron lesion/central pathology~~:~~ include hyperreflexia, clonus, Hoffman sign and Babinski, snout, palmar grasp, and rooting reflexes.

Visual loss has many possible etiologies, and MRI or CT is only indicated in suspected neurological causes of visual loss based on history and exam. Visual field defects, such as bitemporal hemianopsia, ~~or~~ homonymous hemianopsia, or quadranopsia, require imaging as well as does suspected optic nerve pathology. Subjective symptoms such as blurred vision or double vision with no clear correlate on neurological examination requires a comprehensive eye evaluation to exclude more common causes, such as cataracts, refractive errors, retinopathy, glaucoma, or macular degeneration. Transient visual loss with history consistent with TIA but normal exam at time of examination also should be imaged. Positive visual phenomena, such as photopsias or scintillations that march across the visual field, suggest migraine whereas negative phenomenon, such as shaded or blurred, is more characteristic of ischemia.

Imaging for Stroke – ~~Patient~~**Individual**s presenting with symptoms of acute stroke should receive prompt imaging to determine whether they are candidates for treatment with tissue plasminogen activator. Non-contrast CT can evaluate for hemorrhage that would exclude the ~~patient~~**individual** from reperfusion therapy. Functional imaging can be used to select ~~patient~~**individual**s for thrombolytic therapy by measuring the mismatch between "infarct core" and "ischemic penumbra" and may define ischemic areas of the brain with the potential to respond positively to reperfusion therapy. Contrast-enhanced CT angiography (CTA) may follow the non-contrast CT imaging to identify areas of large vessel stenosis or occlusion which may be a target for therapy.

Recent stroke or transient ischemic attack – A stroke or central nervous system infarction is defined as "brain, spinal cord, or retinal cell death attributable to ischemia, based on neuropathological, neuroimaging, and/or clinical evidence of permanent injury. … Ischemic stroke specifically refers to central nervous system infarction accompanied by overt symptoms, whereas silent infarction causes no known symptoms."[107] ~~(Sacco, 2013).~~ If imaging or pathology is not available, a clinical stroke is diagnosed by symptoms persisting for more than 24 hours. Ischemic stroke can be further classified by the type and location of ischemia and the presumed etiology of the brain injury. These include large-artery atherosclerotic occlusion (extracranial or intracranial), cardiac embolism, small-vessel disease and less commonly dissection, hypercoagulable states, sickle cell disease and undetermined causes ~~(Kernan, 2014)~~.[108] TIAs in contrast, "are a brief episode of neurological dysfunction caused by focal brain or retinal ischemia, with clinical symptoms typically lasting less than one hour, and without evidence of acute infarction on imaging."[109] ~~(Easton, 2009).~~ On average, the annual risk of future ischemic stroke after a TIA or initial ischemic stroke is 3–4%, with an incidence as high as 11% over the next 7 days and 24–29% over the following 5 years. This has significantly decreased in the last half century due to advances in secondary prevention ~~(Hong, 2011)~~.[110]

Therefore, when revascularization therapy is not indicated or available in ~~patient~~**individual**s with an ischemic stroke or TIA, the focus of the work-up is on secondary prevention. This includes noninvasive vascular imaging to identify the underlying etiology and to assess immediate complications and risk of future stroke. The majority of stoke evaluations take place in the inpatient setting. Admitting TIA ~~patient~~**individual**s is reasonable if they present within 72 hours and have an ABCD (2) score ≥3, indicating high risk of early recurrence, or the evaluation cannot be rapidly completed on an outpatient basis ~~(Easton, 2009)~~.[109] Minimally, both stroke and TIA should have an evaluation for high-risk modifiable factors, such as carotid stenosis atrial fibrillation, as the cause of ischemic symptoms ~~(Kernan, 2014)~~.[108] Diagnostic recommendations include neuroimaging evaluation as soon as possible, preferably with ~~magnetic resonance imaging~~**MRI**, including DWI; noninvasive imaging of the extracranial vessels should be performed; and noninvasive imaging of intracranial vessels is reasonable ~~(Wintermark, 2013)~~.[111]

~~Patient~~**Individual**s with a history of stroke and recent workup with new signs or symptoms indicating progression or complications of the initial CVA should have repeat brain imaging as an initial study. ~~Patient~~**Individual**s with remote or silent strokes discovered on imaging should be evaluated for high-risk modifiable risk factors based on the location and type of the presumed etiology of the brain injury.

~~**CT and Central Venous Thrombosis** – a CTV or MRV is indicated for the definite evaluation of a central venous thrombosis/dural sinus thrombosis. The most frequent presentations are isolated headache, intracranial hypertension syndrome, seizures, focal neurological deficits, and encephalopathy. Risk factors are hypercoagulable states inducing genetic prothrombotic conditions, antiphospholipid syndrome and other acquired prothrombotic diseases (such as cancer), oral contraceptives, pregnancy, puerperium (6 weeks postpartum), infections, and trauma. Since venous thrombosis can cause SAH, infarctions, and hemorrhage, parenchymal imaging with MRI/CT is also appropriate.[15, 105, 106] (Bushnell, 2014; Courinho, 2015; Ferro, 2016).~~

Imaging of Cavernomas – MRI is the study of choice for detecting cavernous malformations (CCM). Follow-up imaging of known CCM should be done only to guide treatment decisions or to investigate new symptoms. First-degree relatives of ~~patient~~**individual**s with more than one family member with a CCM should have a screening MRI as well as genetic counseling ~~(Akers, 2017; Velz, 2018; Zyck, 2021)~~.[112-114]

Non-aneurysmal vascular malformations – Non-aneurysmal vascular malformations can be divided in low flow vascular malformations and high flow vascular malformations. Low flow vascular malformations include dural venous anomalies (DVA), cavernomas, and capillary telangiectasias. High flow vascular malformations include AVM and dural arteriovenous fistulas (dAVF). For low flow malformations, MRI is the study of choice. ~~There is **limited**~~**Limited** **medical literature is available to support vascular imagining (CTA or MRA). CTA plays a limited role in the assessment of cavernoma but may be used to demonstrate a DVA. MRA is not usually helpful in the assessment of cavernoma, capillary telangiectasia, and DVA. Vascular imaging is indicated in high flow vascular malformations**.[115-117]

CT and Central Venous Thrombosis – ~~a~~A CTV or MRV is indicated for the definite evaluation of a central venous thrombosis/dural sinus thrombosis. The most frequent presentations are isolated headache, intracranial hypertension syndrome (headache, nausea/vomiting, transient visual obscurations, pulsatile tinnitus, CN VI palsy, papilledema),[118] seizures, focal neurological deficits, and encephalopathy. Risk factors are hypercoagulable states inducing genetic prothrombotic conditions, antiphospholipid syndrome and other acquired prothrombotic diseases (such as cancer), oral contraceptives, pregnancy, puerperium (6 weeks postpartum), infections, and trauma. Since venous thrombosis can cause SAH, infarctions, and hemorrhage, parenchymal imaging with MRI/CT is also appropriate.[16, 119, 120]

CT scan for Head Trauma – Most types of head injury are minor injuries; clinical signs and symptoms help predict the need for brain CT following injury. CT has advantages in evaluating head injury due to its sensitivity for demonstrating mass effect, ventricular size and configuration, bone injuries, and acute hemorrhage. A**n** ~~patient~~**individual** who presents with certain clinical risk factors may be more likely to benefit from CT imaging. Some of the clinical risk factors that may be used as a guide to predict the probability of abnormal CT following minor head injury are vomiting, skull fracture, and age greater than 60 years. ~~Patient~~**Individual**s with a Glasgow Coma Scale of 15 or less who also have been vomiting or have a suspected skull fracture are likely to show abnormal results on CT scan. CT is also useful in detecting delayed hematoma, hypoxic-ischemic lesions, or cerebral edema in the first 72 hours after head injury.

CT and ~~benign~~ tumors ~~–~~ ~~tumors~~ ~~(e.g., schwannomas, choroid plexus papilloma, pineocytoma, gangliocytoma) – A single follow-up study is appropriate after the initial diagnosis to ensure stability. Follow-up of known benign tumor is indicated if symptomatic, new/changing signs or symptoms or complicating factors (Gupta, 2017).~~[110] MRI is the ideal modality to follow-up meningioma, pituitary tumors, **low grade tumors,** neurocutaneous syndromes**,** and staging/surveillance for non-CNS cancers. **CT should only be used when MRI is contraindicated or is unable to be obtained.**

Surveillance timelines should follow NCCN guidelines. Imaging is also warranted if the ~~patient~~individual is symptomatic or there are new/changing signs or symptoms or complicating factors.

~~**Meningioma and CT**[30] (NHS, 2018) – CT should only be used when MRI is contraindicated or unable to be obtained. For incidental meningiomas, most patients who progressed do so within 5 years of diagnosis (Islim, 2019).[122] Small (<2cm) meningiomas rarely grow sufficiently to produce symptoms within 5 years. Heavily calcified meningiomas rarely grow. Patients with multiple meningiomas should have annual scans indefinitely, despite treatment because of the possibility of further meningiomas developing.~~

~~For surveillance post-treatment:~~

- ~~Solitary convexity WHO Grade 1 meningiomas - scan at 2½ years post-operatively~~
- ~~Solitary skull base or falcine origin WHO Grade 1 meningiomas- scans at 1 year, 2 years, 3½ years and 5 years post-operatively. If a recurrence is detected, continue annual scans.~~
- ~~WHO Grade 2 meningiomas- scan at 6 months, 1 year then annually to 5 years. If a recurrence is detected, continue annual scans.~~
- ~~WHO Grade 3 meningiomas – 6 monthly scans for 3 years, then annual scans to 5 years. If a recurrence is detected, continue annual scans.~~
- ~~Patients who have had radiosurgery, including those being treated for a recurrence, should have scans at 6 months, then annually for 3 years, a scan at 5 years and a final scan at 10 years.~~

~~**CT scan and Meningitis** – In suspected bacterial meningitis, CT with contrast may be performed before lumbar puncture to show preliminary meningeal enhancement. It is important to evaluate for a mass lesion or cause of elevated ICP that would contraindicate an LP. CT may be used to define the pathology of the base of the skull and that may require therapeutic intervention and surgical consultation. Some causes of an intracranial infection include fractures of the paranasal sinus and inner ear infection.~~

MMSE – The Mini Mental State Examination (MMSE) is a tool that can ~~be used to~~ systematically and thoroughly assess mental status. It is an 11-question measure that tests five areas of cognitive function: orientation, registration, attention and calculation, recall, and language. The MMSE has been the most commonly used measure of cognitive function in dementia research, but researchers have recognized that it is relatively insensitive and variable in mildly impaired individuals. The maximum score is 30. A score of 23 or lower is indicative of cognitive impairment. The MMSE takes only 5-10 minutes to administer and is, therefore, practical to use repeatedly and routinely.

MoCA – The Montreal Cognitive Assessment (MoCA) was designed as a rapid screening instrument for mild cognitive dysfunction. It assesses different cognitive domains: attention and concentration, executive functions, memory, language, visuoconstructional skills, conceptual thinking, calculations, and orientation. MoCA differs from the MMSE mainly by including tests of executive function and abstraction, and by putting less weight on orientation to time and place. Ten of the MMSE's 30 points are scored solely on the time-place orientation test, whereas the MoCA assigns it a maximum of six points. The MoCA also puts more weight on recall and attention-calculation performance, while de-

emphasizing language skill. Time to administer the MoCA is approximately 10 minutes. The total possible score is 30 points; a score of 26 or above is considered normal.

CT for evaluation of the cranial nerves – Magnetic resonance imaging (MRI) is considered the gold standard in the study **and evaluation** of the cranial nerves. Computed tomography (CT) allows, usually, an indirect view of the nerve and is useful to demonstrate the intraosseous segments of cranial nerves, the foramina through which they exit skull base, and their pathologic changes. ~~MRI is the study of choice in the evaluation of the cranial nerves.~~ In optic neuritis, CT has limited utility. Contrast-enhanced CT scanning of the orbits may ~~be able to~~ help exclude other orbital pathology. CT scanning of the brain, regardless of whether intravenous contrast material is administered or not, does not yield prognostic and treatment-altering information. In Bell's Palsy temporal bone CT is useful in the evaluation of the caliber and the course of the IAC and bony facial nerve canal in the temporal bone. When using CT to evaluate the facial nerve, pathology often can only be inferred by visualization of erosion or destruction of the adjacent bony facial nerve canal. In contrast, MRI visualizes soft tissues well and so is better suited for evaluating soft tissue facial nerve abnormalities.

Anosmia – Nonstructural causes of anosmia include post-viral symptoms, medications (Amitriptyline, Enalapril, Nifedipine, Propranolol, Penicillamine, Sumatriptan, Cisplatin, Trifluoperazine, Propylthiouracil). These should be considered prior to advanced imaging to look for a structural cause.

Anosmia and dysgeusia have been reported as common early symptoms in ~~patient~~**individual**s with COVID-19, occurring in greater than 80 percent of ~~patient~~**individual**s. For isolated anosmia, imaging is typically not needed once the diagnosis of COVID has been made, given the high association. As such, COVID testing should be done prior to imaging ~~(Geyer, 2008; Lechien, 2020; Saniasiaya, 2020)~~.[121-123]

Evaluation of olfactory function is essential to determine the degree of chemosensory loss and confirm the ~~patient~~**individual**'s complaint. It also allows monitoring of olfactory function over time, ~~detectomg~~ **detecting** malingerers, and establishing compensation for disability. The~~re are~~ two general types of olfactory testing **are**~~:~~ psychophysical and electrophysiologic testing. Psychophysical tests are used for clinical evaluation of olfactory loss; whereas, electrophysiologic tests, such as electro-olfactogram (EOG) or odor event–related potentials (OERPs), are used for research purposes only.

Olfactory threshold tests rely on measuring detection thresholds of a specific odorant, such as phenyl ethyl alcohol (PEA) or butyl alcohol. Odor identification tests are quantitative tests in which ~~patient~~**individual**s are asked to identify the odorants at the suprathreshold level. Examples include *The Connecticut odor identification, The University of Pennsylvania Identification Test (UPSIT) and the Cross-Cultural Smell Identification Test (CC-SIT)*. In Europe, a commonly used test is a threshold- and odorant-identification forced-choice test that uses odorant-impregnated felt-tipped pens (Sniffin' Sticks). A simple olfactory screening test using a 70% isopropyl alcohol pad as a stimulant has also been well described in the literature ~~(Wrobel, 2004)~~.[124]

CT scan for congenital abnormalities – While MRI is preferred to CT for evaluation of most congenital CNS abnormalities, in some clinical situations CT is preferred (craniosynostosis) or equivalent to MRI. CT is appropriate in the follow-up of hydrocephalus or VP shunt function where the etiology of

hydrocephalus has been previously determined or in ~~patient~~**individual**s for which MRI evaluation would require general anesthesia.

CT for Macrocephaly – Consider ultrasound in infants with macrocephaly and a normal neurological examination, no evidence of increased ICP, and an open anterior fontanelle. If head US is normal, the infant should be monitored closely ~~(Smith, 1998)~~.[125] The anterior fontanelle generally closes between 10 and 24 months of age, with 3% closing between 5-9 months and 11% after 24 months ~~(Pindrik, 2014)~~.[126]

CT and Normal Pressure Hydrocephalus (NPH) – Although diagnosis can be made based on CT findings alone, MRI is more accurate for disclosing associated pathologies (such as cerebrovascular disease), excluding other potential etiologies, and for detecting NPH typical signs of prognostic value. A CT scan can exclude NPH and is appropriate for screening purposes and in ~~patient~~**individual**s who cannot undergo MRI.

CT and Vertigo – The most common causes of vertigo seen are benign paroxysmal positional vertigo (BPPV), vestibular neuronitis (VN) and Ménière's disease. These peripheral causes of vertigo are benign, and treatment involves reassurance and management of symptoms. Central causes of vertigo, such as cerebrovascular accidents (CVAs), tumors and multiple sclerosis (MS), need to be considered if the ~~patient~~**individual** presents with associated neurological symptoms, such as weakness, diplopia, sensory changes, ataxia or confusion. Magnetic resonance imaging is appropriate in the evaluation of ~~patient~~**individuals** with vertigo who have neurologic signs and symptoms, progressive unilateral hearing loss or risk factors for cerebrovascular disease. MRI is more appropriate than CT for diagnosing vertigo due to its superiority in visualizing the posterior portion of the brain, where most central nervous system disease that causes vertigo is found. A full neurologic and otologic evaluation including provocative maneuvers, vestibular function testing and audiogram can help evaluate vertigo of unclear etiology and differentiate between central and peripheral vertigo.

CT and developmental delay – Significant developmental delay is defined as significant delay (more than two standard deviations below the mean) in one or more developmental domains: gross/fine motor, speech/language, cognition, social/personal, and activities of daily living. Isolated delay in social/language development is characteristic of autism spectrum disorders or hearing loss. Isolated delay in motor development is characteristic of cerebral palsy (a static encephalopathy) or myopathy. Global developmental delay (GDD) is a subset of developmental delay defined as significant delay (by at least 2 SD's) in two or more developmental categories. Note that the term "GDD" is usually reserved for children < 5 years old, whereas in older children > 5 years, disability is quantifiable with IQ testing.

CT scan and Meningitis – In suspected bacterial meningitis, CT with contrast may be performed before lumbar puncture **(LP)** to show preliminary meningeal enhancement. It is important to evaluate for a mass lesion or cause of elevated ICP that would contraindicate an LP. CT may be used to define the pathology of the base of the skull and that may require therapeutic intervention and surgical consultation. Some causes of an intracranial infection include fractures of the paranasal sinus and inner ear infection.

Leptomeningeal Carcinomatosis[127-130] **– Leptomeningeal metastasis is an uncommon and typically late complication of cancer with poor prognosis and limited treatment options. Diagnosis is often challenging with nonspecific presenting symptoms ranging from headache and confusion to focal neurologic deficits such as cranial nerve palsies. Standard diagnostic evaluation involves a neurologic examination, MRI of the brain and spine with gadolinium, and cytologic evaluation of the cerebral spinal fluid (CSF). Hematologic malignancies (leukemia and lymphoma), primary brain tumors as well as solid malignancies can spread to the leptomeninges. The most common solid tumors giving rise to LM are breast cancer (12 - 35 %), small and non-small cell lung cancer (10-26 %), melanoma (5 -25 %), gastrointestinal malignancies (4-14 %), and cancers of unknown primary (1-7 %).**

Drop Metastases – Drop metastases are intradural extramedullary spinal metastases that arise from intracranial lesions. Common examples of intracranial neoplasms that result in drop metastases include pineal tumors, ependymomas, medulloblastomas, germinomas, primitive neuroectodermal tumors (PNET), glioblastomas multiform, anaplastic astrocytomas, oligodendrogliomas and less commonly choroid plexus neoplasms and teratomas.[131]

POLICY HISTORY

Date	Summary
May 2022	Updated and reformatted references Updated background section Combo statement added Reorganized indications Changed visual deficits section added to background Clarified: • Acute headache, sudden onset • New onset headache related to activity or event (sexual activity, exertion, position), new or progressively worsening • Visual loss in background/removed note • Histiocytic Neoplasms (Erdheim-Chester Disease, Langerhans Cell Histiocytosis, and Rosai-Dorfman Disease) for screening and/or with neurological signs or symptoms • Follow-up of known CNS cancer (either primary malignant brain tumor or secondary brain metastasis) as per NCCN • Tumor monitoring in neurocutaneous syndromes as per tumor type • Histiocytic Neoplasms (Erdheim-Chester Disease, Langerhans Cell Histiocytosis, and Rosai-Dorfman Disease) To assess treatment response and surveillance of known brain/skull lesions • Examples of mental status instruments to screen for cognitive impairment • Binocular diplopia with concern for intracranial pathology after comprehensive eye evaluation • Evaluation of cranial nerve palsy/neuropathy/neuralgia. Brain MRI is the study of choice if indicated Added: • Abnormal reflexes to neurologic deficit sections • High stroke risk in sickle cell patients (2 - 16 years of age) with a transcranial doppler velocity > 200 when MRI is contraindicated or cannot be performed (Also in Combo Brain CT/CTA) • Suspected Pituitary Tumors Brain MRI is the study of choice if indicated or Sella CT if MRI is contraindicated or cannot be performed • For screening for known non-CNS Cancer and for screening of hereditary cancers syndromes Brain MRI is the study of choice if indicated • Follow-up of known low grade tumor (WHO I-II) (i.e., meningioma, glioma, astrocytoma, oligodendroglioma) ○ For surveillance as per NCCN

	○ If symptomatic, new/changing signs or symptoms or complicating factors • Known pituitary tumors Brain MRI is the study of choice if indicated or Sella CT if MRI is contraindicated or cannot be performed • Seizure disorder, Movement disorders: Brain MRI is the study of choice if indicated • Tourette syndrome to list of movement disorders in which MRI is not indicated • Bulbar or pseudobulbar symptoms when MRI is contraindicated or cannot be performed • For initial evaluation of a suspected Arnold Chiari malformation • Follow-up imaging of a known type II or type III Arnold Chiari malformation. For Arnold Chiari type I, follow-up imaging only if new or changing signs/symptoms • General Combo statement Note: These body regions might be evaluated separately or in combination as documented in the clinical notes by physical examination findings (e.g., localization to a particular segment of the neuroaxis), patient history, and other available information, including prior imaging. • Combo Brain CT/CTA: ○ Neurological signs or symptoms in sickle cell patients ○ Note: MRA and CTA are generally comparable noninvasive imaging alternatives each with their own advantages and disadvantages. ▪ Brain MRI can alternatively be combined with Brain CTA/Neck CTA. • Combo Brain CT/ Cervical CT/Thoracic CT/Lumbar CT (mirrors MRI) ○ Arnold Chiari ○ Oncological Applications ○ CSF leak Deleted: • Patient with history of CNS cancer (either primary or secondary) and a recent course of chemotherapy, radiation therapy (to the brain), or surgical treatment within the last two (2) years Follow-up of known meningioma section/background ~~Updated and reformatted references~~ ~~Updated background section~~ ~~Combo statement added~~ ~~Reorganized indications~~

	~~Changed visual deficits section added to background~~ ~~Clarified:~~ - ~~Acute headache, sudden onset~~ - ~~New onset headache related to activity or event (sexual activity, exertion, position), new or progressively worsening~~ - ~~Visual loss in background/removed note~~ - ~~Histiocytic Neoplasms (Erdheim-Chester Disease, Langerhans Cell Histiocytosis, and Rosai-Dorfman Disease) for screening and/or with neurological signs or symptoms~~ - ~~Follow-up of known CNS cancer (either primary malignant brain tumor or secondary brain metastasis) as per ACCN~~ - ~~Tumor monitoring in neurocutaneous syndromes as per tumor type~~ - ~~Histiocytic Neoplasms (Erdheim-Chester Disease, Langerhans Cell Histiocytosis, and Rosai-Dorfman Disease) To assess treatment response and surveillance of known brain/skull lesions~~ - ~~Examples of mental status instruments to screen for cognitive impairment~~ - ~~Binocular diplopia with concern for intracranial pathology after comprehensive eye evaluation~~ - ~~Evaluation of cranial nerve palsy/neuropathy/neuralgia. **Brain MRI** is the study of choice if indicated~~ ~~Added:~~ - ~~Abnormal reflexes to neurologic deficit sections~~ - ~~High stroke risk in sickle cell patients (2 – 16 years of age) with a transcranial doppler velocity > 200 when MRI is contraindicated or cannot be performed (Also in Combo Brain MRI/MRA)~~ - ~~Suspected Pituitary Tumors **Brain MRI** is the study of choice if indicated or Sella CT if MRI is contraindicated or cannot be performed~~ - ~~For screening for known non-CNS Cancer and for screening of hereditary cancers syndromes **Brain MRI** is the study of choice if indicated~~ - ~~Added hyperlinks to Brain Guidelines~~ - ~~Follow-up of known low grade tumor (WHO I-II) (i.e., meningioma, glioma, astrocytoma, oligodendroglioma)~~ - ~~For surveillance as per ACCN~~ - ~~Known pituitary tumors **Brain MRI** is the study of choice if indicated or Sella CT if MRI is contraindicated or cannot be performed~~ - ~~Seizure disorder, Movement disorders: **Brain MRI** is the study of choice if indicated~~ - ~~Tourette syndrome to list of movement disorders in which MRI is not indicated~~

	~~Bulbar or pseudobulbar symptoms when MRI is contraindicated or cannot be performed~~ ~~For initial evaluation of a suspected Arnold Chiari malformation~~ ~~Follow-up imaging of a known type II or type III Arnold Chiari malformation. For Arnold Chiari type I, follow-up imaging only if new or changing signs/symptoms~~ ~~**General Combo statement**~~ ~~Note: These body regions might be evaluated separately or in combination as documented in the clinical notes by physical examination findings (e.g., localization to a particular segment of the neuroaxis), patient history, and other available information, including prior imaging.~~ ~~**Combo Brain MRI/MRA**:~~ ~~Neurological signs or symptoms in sickle cell patients~~ ~~Note: MRA and CTA are generally comparable noninvasive imaging alternatives each with their own advantages and disadvantages. Brain MRI can alternatively be combined with Brain CTA/Neck CTA.~~ ~~**Combo Brain CT/ Cervical CT/Thoracic CT/Lumbar CT** (mirrors MRI)~~ ~~Arnold Chiari~~ ~~Oncological Applications~~ ~~CSF leak~~ ~~Deleted:~~ ~~Patient with history of CNS cancer (either primary or secondary) and a recent course of chemotherapy, radiation therapy (to the brain), or surgical treatment within the last two (2) years~~ • ~~Follow-up of known meningioma section/background~~
July 2021	Reordered Indications Updated references Updated background section Added • Brain MR/MRA are not approvable simultaneously unless they meet the criteria described below in the Indications for Brain MR/Brain MRA combination studies section. • ***‡ Designates when CT is indicated only when MRI is contraindicated or cannot be performed*** • Added ‡ after appropriate indications • Cluster headaches or other trigeminal-autonomic cephalgias i.e. paroxysmal hemicrania, hemicrania continua, short-lasting unilateral neuralgiform headache attacks (SUNCT/SUNA) imaging is indicated once to eliminate secondary causes (IHS, 2018)

	• Langerhans cell histiocytosis with visual, neurological, or endocrine abnormality; polyuria or polydipsia; suspected craniofacial bone lesions, aural discharge, or suspected hearing impairment/mastoid involvement • Langerhans cell histiocytosis - To assess treatment response and surveillance of known brain/skull lesions • similar mental status instruments */formal neuropsychological *Other examples include Ottawa 3DY (O3DY), Brief Alzheimer's Screen (BAS), Blessed Dementia Scale (BDS), caregiver-completed AD8 (cAD8), Brief Cognitive Rating Scale (BCRS), Clinical Dementia Rating (CDR) (Carptenter, 2011; McDougall, 1990) • Optic atrophy as an abnormal eye finding • Childhood strabismus with development delay or abnormal fundoscopic exam to rule out intracranial abnormalities • Evaluation of the corticomedullary junction in Achondroplasia • Evaluation of suspected hydrocephalus with any acute, new, or fluctuating neurologic, motor, or mental status changes (separated this from known hydrocephalus) • Cisternography for intermittent and complex CSF rhinorrhea/otorrhea. CSF fluid should always be confirmed with laboratory testing (Beta-2 transferrin assay). • Suspected carotid or vertebral artery dissection with focal or lateralizing neurological deficits to Brain CT/Brain CTA/Neck CTA combo • Headache associated with exercise or sexual activity (Brain CT/Brain CTA combo) • Pre-operative evaluation for a planned surgery or procedure Clarified • Symptoms indicative of *increased* intracranial pressure, such as recurring headaches after waking with or without associated nausea/vomiting • Suspected stroke with a personal or *first-degree* family history (brother, sister, parent, or child) of aneurysm or known coagulopathy or on anticoagulation • Symptoms of transient ischemic attack (TIA) *(episodic neurologic symptoms such as sensory deficits, limb weakness, speech difficulties, visual loss, lack of coordination, or mental status changes)* • Known or suspected skull fracture by physical exam and*/or prior imaging* • Central Nervous System (CNS) involvement in patients with known or suspected vasculitis or autoimmune disease *with abnormal inflammatory markers or autoimmune antibodies*

	• Suspected primary CNS vasculitis based on neurological signs and symptoms with completed infectious/inflammatory lab work-up • Anosmia *or dysosmia* on objective testing that is persistent and of unknown origin (also in combo section) • Evaluation of cranial neuropathy when thought to be due to tumor, stroke, or bony abnormalities of the skull base *or when MRI is contraindicated or cannot be performed* • Clarified age < 18 for imaging of microcephaly and macrocephaly • After full neurologic examination and vestibular testing with concern for central vertigo (i.e. skew deviation, vertical nystagmus, head thrust test, videonystagmography (VNG/electronystagmography (ENG)) • Clarified age < 18 for imaging of developmental delay • Optic neuropathy or unilateral optic disk swelling of unclear etiology (Brain CT/Orbit CT) Deleted • Brain CT/Cervical CT - for evaluation of Arnold Chiari Malformation
May 2020	Clarified: • New onset headache with (neurologic deficit) or with signs of increased intracranial pressure **(papilledema)** • Special additional considerations in the pediatric population with persistent headache ○ Documented absence of family history of headache • Suspected **brain** tumor • Suspected **brain metastasis or intracranial involvement** in patients with a history of cancer based on neurological symptoms or examination findings • Follow up of known malignant **brain** tumor • Patient with history of **CNS** cancer **(either primary or secondary)** and a recent course of chemotherapy, radiation therapy (to the brain), or surgical treatment within the last two (2) years • Follow up of known **non-malignant brain** tumor/**lesion** if symptomatic, new/changing signs or symptoms or complicating factors • **Suspected** intracranial abscess or brain infection • Suspected Encephalitis with headache and altered mental status or follow-up as clinically warranted • Mental status score of either MMSE or MoCA of less than 26 or other similar mental status instruments/**neuropsychological testing** • Vertigo associated with any of the following

	○ Risk factors for cerebrovascular disease **with concern for stroke** ○ After full neurologic examination and **vestibular testing** with concern for central vertigo • Combo Brain MRI/Orbit MRI ○ Reworded: Unilateral **optic disk swelling/optic neuropathy of unclear etiology** to distinguish between a compressive lesion of the optic nerve, optic neuritis, ischemic optic neuropathy (arteritic or non-arteritic), central retinal vein occlusion or optic nerve infiltrative disorders ○ Bilateral **optic disk swelling** (papilledema) with vision loss Added: • Visual loss (as a neurological deficit) Not explained by underlying ocular diagnosis, glaucoma or macular degeneration • Under New acute headache, sudden onset: ○ With a **personal** or family history of brain aneurysm or AVM (arteriovenous malformation) ○ Known coagulopathy or on anticoagulation • Under New onset of headache and any of the following ○ Fever ○ Subacute head trauma ○ Age > 50 ○ Neurological deficits - Note: Neuroimaging warranted for atypical/complex migraine aura, but not for a typical migraine aura (see background) • Special additional considerations in the pediatric population with persistent headache ○ Symptoms indicative of intracranial pressure, such as recurring headaches after waking with or without associated nausea/vomiting ○ Severe headache in a child with an underlying disease that predisposes to intracranial pathology (e.g.; immune deficiency, sickle cell disease neurofibromatosis, history of neoplasm, coagulopathy, hypertension, congenital heart disease) • Suspected stroke with a personal or family history (brother, sister, parent or child) of aneurysm or known coagulopathy/anticoagulation • Suspected recurrence with prior history of CNS cancer based on neurological symptoms or examination • Binocular diplopia with concern for intracranial pathology • Follow up shunt evaluation (Pople, 2002, Reddy, 2014, Kamenova, 2018)

	○ Post operatively if indicated based on underlying disease and pre-operative radiographic findings and/or ○ 6-12 months after placement and/or ○ With neurologic symptoms that suggest shunt malfunction • Suspected spontaneous intra-cranial hypotension with distinct postural headache other symptoms include: nausea, vomiting, dizziness, tinnitus, diplopia neck pain or imbalance • Diagnosis of central sleep apnea on polysomnogram ○ Children > 1 year ○ Adults in the absence of heart failure, chronic opioid use, high altitude, or treatment emergent central sleep apnea AND concern for a central neurological cause (Chiari malformation, tumor, infectious/inflammatory disease) OR with an abnormal neurological exam • Syncope with clinical concern for seizure or associated neurological signs or symptoms • Cyclical vomiting syndrome or abdominal migraine with any localizing neurological symptoms • Soft tissue mass of the head with nondiagnostic initial evaluation (ultrasound and/or radiograph) • Cerebral palsy if etiology has not been established the neonatal period, there is change in the expected clinical or developmental profile or concern for progressive neurological disorder • Unexplained event (BRUE) formerly apparent life-threatening event (ALTE) in infants < 1 year with concern for neurological cause based on history and exam • Note: Imaging is not indicated in low risk patients Deleted: • Under New onset of headache and any of the following ○ Temporal headache in person > 55, with sedimentation rate (ESR) > 55 with tenderness over the temporal artery. • Known brain tumor and new onset of headache. • Removed the statement when MRI is contraindicated or cannot be performed throughout the document and • Replaced with Important Note: Brain MRI is preferred to Brain CT in most circumstances where the patient can tolerate MRI and sufficient time is available to schedule the MRI examination. Assessment of subarachnoid hemorrhage, acute trauma or bone abnormalities of the calvarium (fracture, etc.) may be better imaged with CT. **CT is also appropriate in an urgent situation where MRI is not readily available (stroke, increased ICP, CNS infection).**

	Clarified:
	• Cluster headaches- imaging is indicated once to eliminate secondary causes
	• Evaluation of cranial neuropathy when thought to be due to tumor, stroke, or bony abnormalities of the skull base
	
	Added:
	• For evaluation of movement disorders
	  ○ Acute onset of a movement disorder with concern for stoke or hemorrhage
	  ○ For evaluation of Parkinson's disease with atypical feature or other movement disorder (i.e., suspected Huntington disease, chorea, parkinsonian syndromes, hemiballismus, atypical dystonia) to exclude an underlying structural lesion
	Notes: CT has limited utility in the chronic phases of disease. Imaging is not indicated in essential tremor or isolated focal dystonia (e.g., blepharospam, cervical dystonia, laryngeal dystonia, oromandibular dystonia, writer's dystonia)
	• Combo Brain CT/CTA
	  ○ Recent ischemic stroke or transient ischemic attack
	  ○ Acute, sudden onset of headache with personal history of a vascular abnormality or first-degree family history of aneurysm
	
	Deleted:
	• Combo Brain CT/CTA
	  ○ Clinical suspicion of subarachnoid hemorrhage (SAH) ie thunderclap headache

August 2019	• For evaluation of neurologic symptoms or deficits, added: visual loss
	• For trauma, added:
	  ○ On anticoagulation
	  ○ Post concussive syndrome if persistent or disabling symptoms and imaging has not been performed
	  ○ Subacute or chronic traumatic brain injury with new cognitive and/or neurologic deficit and cannot have an MRI
	• For evaluation of headache, added:
	  ○ Prior history of stroke or intracranial bleed with sudden onset of severe headache(moved)
	  ▪ Related to activity or event (sexual activity, exertion, position) (new or progressively worsening)

	▪ New headaches and persistent or progressively worsening during a course of physician directed treatment ▪ Special considerations in the pediatric population with persistent headache: • Occipital location • Age < 6 years • No family history of headache ○ Specified when MRI is contradicted for cluster headaches to eliminate secondary causes • For evaluation of brain tumor: ○ Specified 'malignant' for f/u of known tumor ○ Added: Follow up of known benign tumor if symptomatic, new/changing signs or symptoms or complicating factors; Follow up of known meningioma if MRI is contraindicated ○ Removed: Known lung cancer or rule out metastasis and/or preoperative evaluation, Metastatic melanoma (not all melanomas) • For evaluation of suspected stroke: ○ Moved 'patient with history of a known stroke with new and sudden onset of severe headache' ○ Separated: Family history of aneurysm • For evaluation inflammatory disease or infections: ○ Changed meningitis with positive signs and symptoms from 'And' positive lab findings to 'OR' positive labs ○ For suspected encephalitis removed 'severe' headache • For evaluation of congenital abnormality: ○ Modified the age restriction of > 6 months age for eval of macrocephaly to include 'in an infant/child with previously abnormal US, abnormal neurodevelopmental exam, signs of increased ICP or closed anterior fontanelle' and MRI is contraindicated • For suspected normal pressure hydrocephalus added 'with symptoms of gait difficulty, cognitive disturbance, and urinary incontinence • Other indications: ○ Added detail to Vertigo when MRI is contraindicated including: ▪ Signs or symptoms suggestive of a CNS lesion (ataxia, visual loss, double vision, weakness, or a change in sensation) ▪ Progressive unilateral hearing loss ▪ Risk factors for cerebrovascular disease

	▪ After full neurologic examination and ENT work-up with concern for central vertigo ○ Modified developmental delay to include: Global developmental delay or developmental delay with abnormal neurological examination ○ Added: ▪ Abnormal eye findings on physical or neurologic examination (papilledema, nystagmus, ocular nerve palsies, new onset anisocoria, visual field deficit etc). ▪ Horner's syndrome with symptoms localizing the lesion to the central nervous system ▪ Psychological changes with neurological deficits or a full neurological assessment completed that suggests a possible neurologic cause and MRI cannot be performed • For Brain CT/Neck CTA: added 'Suspected carotid or vertebral artery dissection with focal or lateralizing neurological deficits' ○ Removed Confirmed carotid occlusion >60%, surgery or angioplasty candidate • Added Brain CT/Brain CTA section, including: Clinical suspicion of subarachnoid hemorrhage (SAH) ie thunderclap headache; AND Suspected venous thrombosis (dural sinus thrombosis) • Added Brain CT/Brain CTA/Neck CT section, including: Recent stroke or transient ischemic attack (TIA); AND Approved indications as noted above and being performed in a child under 8 years of age who will need anesthesia for the procedure and there is a suspicion of concurrent intracranial pathology • For Brain CT/Orbit CT, added: Bilateral papilledema with visual loss; AND changed age restriction from 3 years to 8 years for children requiring anesthesia for the procedure with suspicion of concurrent orbital and intracranial pathology or tumor • Updated background information and references

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~~Reviewed / Approved by NIA Clinical Guideline Committee~~

~~**GENERAL INFORMATION**~~

~~It is an expectation that all patients receive care/services from a licensed clinician. All appropriate supporting documentation, including recent pertinent office visit notes, laboratory data, and results of any special testing must be provided. If applicable: All prior relevant imaging results and the reason that alternative imaging cannot be performed must be included in the documentation submitted.~~

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ADDITIONAL RESOURCES

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Reviewed / Approved by NIA Clinical Guideline Committee

GENERAL INFORMATION

It is an expectation that all patients receive care/services from a licensed clinician. All appropriate supporting documentation, including recent pertinent office visit notes, laboratory data, and results of any special testing must be provided. If applicable: All prior relevant imaging results and the reason that alternative imaging cannot be performed must be included in the documentation submitted.